SEATTLE STEAMER on line

September 1999 Volume 10, Number 3

ON STRESSES, FACTORS OF SAFETY, AND ALL THAT BY GIOVANNI

I must confess that I do not look forward to updating my ASME Boiler and Pressure Vessel Codes with new addenda as much as I used to. It could be old age (which is like saying my values have shifted), or it could be that, like brain surgery, only the first couple hundred brains are fun. The fact is that I feel robbed from the anticipation every boiler inspector feels before he or she starts to tear into all that pink, white, and blue mess of pages. I am old enough to remember when codes had to be bound. Do you remember the fun we had with glue and scissors? Yikes!

When I began to insert the 1999 addenda (the pink one) yesterday, I noticed that the stress values in Section D were all different. And then, I remembered talks about bringing the safety factor from **4** to **3.5,** and all the controversy that it generated.

"That must be it" I said to myself, and the adrenaline began to flow.

Actually, provisions for using a lower factor of safety were already available under ASME Code Cases 2278, 2284, and 2290. However, code cases had to be identified in the data report, and some jurisdictions were not allowing them anyway.

As of this writing, I have not received all the addenda, and I do not know if those code cases have been rescinded or not, but I presume that sooner or later they will. Also, up to this point, I have not seen any specific mention of this philosophy change, just different stress factors, but, as I said, I am still shuffling pink pages and I have not yet read all the changes.

What does this all mean? Well, it is too early to say. Probably not much in terms of domestic competition, as all code shops work out of the same book, but certainly the impact on international competition will be larger.

As an illustration, I took a Section VIII, Division 1 200 psi vessel, 40" in diameter, made of SA 285-C steel, and I used an efficiency of 1. As they say in the commercials, the thickness before the cure was 0.292", and that went to 0.257" or a reduction of 12% in shell thickness alone. And that is what a 13.8% increase in the allowable stress will buy you. The other side of the picture is that a vessel of the same thickness will now be able to be stamped 227 psi. A lot of people in the business are bothered by this, since we have not changed the material, just the paper on which the stresses are printed on.

From the manufacturing point of view, since things are linear, the savings in steel weight in the shell alone, will also be 12%, but then, there are savings in welding materials, welding hours, post weld heat treatment (some vessels may be below the required thickness now or may require less time), shipping, handling, just to name the first items that come to mind.

I would like to point out that there are circumstances in design where the circumferential stress is not the only governing factor, and a thicker shell may be required because of external loads, corrosion, cyclic conditions, etc. Fatigue loading throws an in-

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Also in this issue:

I’m Doin’ Ninety and I Ain’t Scary…

By Chris Villa

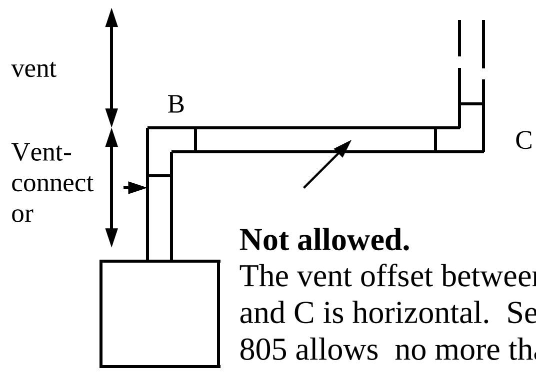
Ok, so the mechanical code is written in a different language! For instance, Section 805 on length, pitch and clearances of gravity venting systems. 805.1 establishes that gravity vents shall be generally vertical, with offsets not exceeding 45°. Please note the word “shall”. This is not a code writer’s attempt to sound like Shakespeare. “Shall” indicates this point is not open to negotiation. Having said that, it is then stated that one 60° offset is allowed. So, no 90° elbows in the vent!

Now comes the tough part. As we read the second paragraph, we note that any part of the vent greater than 45° is considered “horizontal”. And that the total horizontal run (including the horizontal portion of the vent connector) may not exceed 75% of the total vertical height of the vent. Is this part saying the vent may now be horizontal? After all, it refers to the “horizontal run of a vent”. Clear as mud.

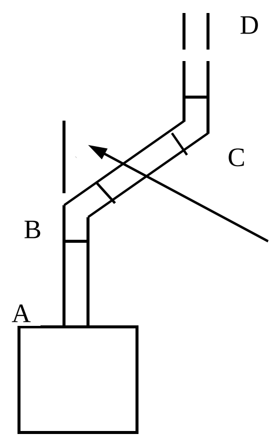
Ok, refer back to the “shall be generally vertical” part. We’re already limited to 45° from the vertical, with one 60° offset allowed. Anything from 46° through 60° must be counted towards the “horizontal” portion of the vent which may not exceed 75% of the total vertical rise.

It may help to remember the distinction between “connector” and “vent”. Section 815 talks about connectors. We see that the connector attaches the appliance to the vertical vent or chimney, and is in the same room or area as the appliance. Further, the connector may be practically horizontal (1/4” slope “up” per foot). There are many other fascinating details about connectors in this section one dare not miss. Not to mention the “rabbit trails” to other sections.

Remember, a gravity vent or chimney is vertical, and the connector stays in the room with the appliance. No 90° offsets in the vent! Suffice it to say that the rules about venting fuel-fired appliances have all the twists and turns of a snake, and if one isn’t careful, that’s exactly how the vent may wind up looking!



Not allowed.
The vent offset between B and C is horizontal. Section 805 allows no more than one 60 degree offset or any number of 45 degree offsets.



One 60 degrees vent offset is allowed, but the horizontal part B to C must not exceed 75% of the A to D run.

If the boiler is of a size requiring enclosure in a fire rated boiler room under the building code, the part of the venting system outside the boiler room and up to the roof will also require enclosure in a fire rated chase.
There are times when the above geometry is not possible. That is when a mechanical draft system is the only solution. That is covered in Section 817 of the Mechanical Code. The position of the fan is important. If listed B vent was used, the fan will have to go at the exit (B vents cannot be pressurized). The fan will have to be interlocked with the boiler, so that the boiler will not come on if the fan is not running.

Steam Boiler Chemistry

by James Dorwin

As a boiler and machinery inspector, I perform many inspections and tests on these not so well known machines. Steam boilers have a very distinct place in history, as they were the driving force behind bringing the world into the Industrial Revolution. Steam changed the way the world worked. With the invention of steam-powered machinery, corporations could mass-produce many times more products than before. However, along with this new business catalyst, came severe neglect. Steam boilers can be used, or misused, is such a manner as to cause severe catastrophic accidents or failures. As with any machine, boilers must be maintained and operated under strict controls. Within these controls, exists boiler water chemistry.

Steam boilers, whether used for commercial production or for heating buildings, require water treatment in order to minimize the adverse effects of corrosion and scaling. Since steam boilers require water to make steam, this makeup water must be treated with chemicals to reduce the amount of dissolved oxygen and metal deposits present which lead to corrosion and scaling. Boilers are fairly expensive machines. Maintaining a boiler is costly and requires much attention. In addition to this, boilers can become very hazardous should they become weakened by corrosion. The explosive power of steam is very well known and should always be respected. Thousands of injuries and deaths have resulted from steam boiler failures throughout history.

Corrosion is the process of deteriorating metal. Initially, new oxygen-free water, entering the boiler produces a chemical reaction between the metal surfaces (iron) and the water. This results in the formation of a microscopically thin layer of magnetic iron oxide (magnetite). This layer of magnetite protects the iron it covers, and further corrosion is limited as long as the pH concentration of the water avoids becoming acidic. An acidic condition will damage the coating, leaving vulnerable metal exposed to the perils of free oxygen. Any damage to this coating will allow corrosion to spread. Water in contact with air will contain a certain amount of dissolved oxygen. The amount of oxygen that will dissolve in water depends upon the temperature of the water and pressure acting on the surface of the water.

Although oxygen is more readily dissolved in water at lower temperatures, the solubility increases as the external pressure increases. When water containing dissolved oxygen enters the boiler, the dissolved oxygen causes localized corrosion and pitting of metal. The oxygen dissolved in the boiler water reacts with the iron of the boiler waterside metal. The iron dissolves and forms a substance known as ferrous hydroxide. Some of this ferrous hydroxide is converted to hydrated ferric oxide. The mixture of ferrous hydroxide and hydrated ferric oxide is dehydrated and forms black iron oxide. This black iron oxide undergoes a change on the metal surface, a further reaction with oxygen, which results in a reddish iron oxide.

As the oxygen attack continues over a period of time, the iron metal is dissolved and active oxygen causes tubercles (scabs). A tubercle has a hard, reddish brown outer shell. The shell covers a pit in the boiler metal. There may be one to many of these pits. Once an active oxygen scab forms, the corrosion of the metal continues, even though the condition causing dis-

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solved oxygen contamination in the boiler water has been corrected. As the pH of the water decreases, the severity of the dissolved oxygen attack increases. Thus, the addition of chemicals that will "scavenge," or remove this dissolved oxygen is essential. In addition, chemicals that control pH levels in the boiler are also required. Sodium sulfite is usually added to combine with the free oxygen to form sodium sulfate. Sodium hydroxide is typically added to increase the alkalinity of the boiler water and to precipitate out certain salts out of solution, such as magnesium.

Scaling is the process of lining heat transfer surfaces with an undesirably hard insulating material. This material is typically made from calcium, magnesium, and silica compounds in the water. Higher temperatures encountered in the operation of a boiler help these compounds form, due to an increase in their solubility. Phosphates are typically added to form a soft sludge compound, which can be flushed easily from the boiler. Disodium phosphate chemically combines with magnesium and calcium to form magnesium phosphate and calcium phosphate, respectively.

Boilers have proven the tests of time with years of reliable and safe operation. As long as they are cared for in a matter consistent with good engineering practices, they can theoretically last forever. Neglected, or misused, boilers can lead to devastating financial or safety concerns. Chemistry is a crucial aspect of an effective boiler maintenance program.

CARBON MONOXIDE POISONING PREVENTABLE WITH COMPLETE INSPECTION

by Regina Romany and Lee Doran

Extracted by Giovanni Ranieri from the Spring 1995 *National Board Bulletin* with the gracious permission of Lee Doran, National Board Consultant

When it comes to boiler accidents, most people relate to a boiler explosion or a combustion chamber explosion. Yet, accidents involving carbon monoxide (which does not cause any damage to the boiler) are more frequent than the other two combined.

According to the U.S. Consumer Product Safety Commission, an estimated 250 persons die and almost 5,000 are injured each year in non-fire related carbon monoxide poisoning. Estimates of non-fatal injuries are difficult to determine because many victims do not seek treatment or are misdiagnosed as having colds or influenza. However, these estimates suggest that there are 20 non-fatal injuries for every fatal carbon monoxide poisoning.

Accident investigation results consistently attribute blame to the venting systems. But venting is actually only part of the problem. Further investigation would reveal that that it is the burner that isn't operating properly. When the burner is not receiving enough air, unburned fuel is released in the form of carbon monoxide and soot. The root cause of any carbon monoxide emission is the burner operating without enough air.

It is extremely important that the **entire** boiler be inspected, including all connecting apparatus and auxiliary equipment. Inspection of the **entire** boiler as a complete system is the only way to ensure safe operation. And if the burner is not receiving sufficient air, combustion air must be the first step in the inspection.

Many jurisdictions have adopted ASME CSD-1 Controls and Safety Devices for Automatic Fired Boilers. Twenty-eight states and jurisdictions of the U.S and Canada require at least part of CSD-1. The standard addresses combustion equipment requirements as well as steam and waterside controls, testing, and operation requirements. As the standard becomes more widely known and used, personnel in fire prevention and boiler safety are recognizing the interdependence of a boiler's pres-

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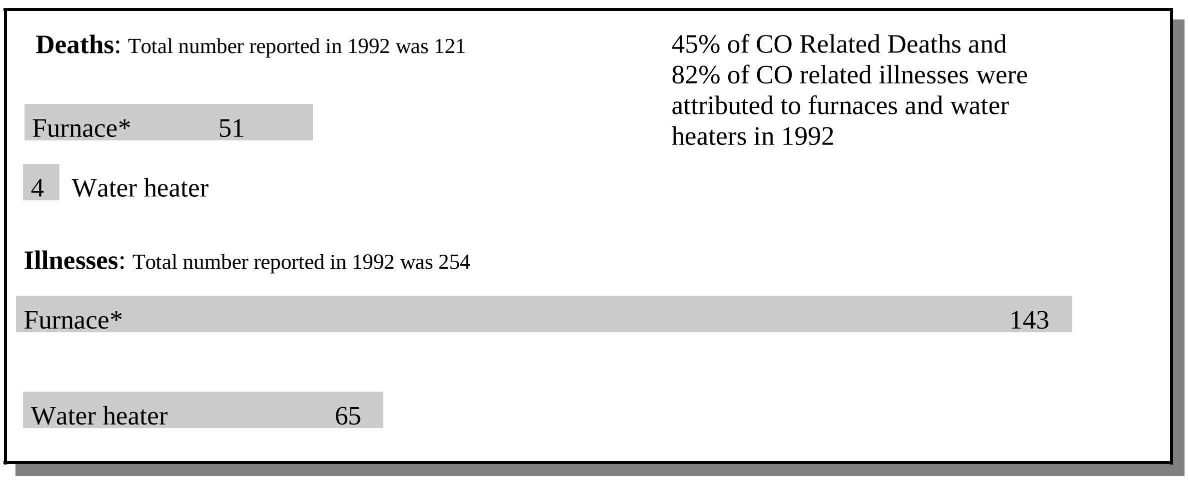
sure and fuel-firing apparatus. (note 1)

But prevention of carbon monoxide poisoning does not stop with an appropriate inspection. Proper care, testing and maintenance are vital. Due to budgetary constraints, public and other commercial buildings are often forced to forgo training for their boiler maintenance and operating personnel. Other times, management does not recognize the need for training of personnel in this extremely vital area. Jurisdictions requiring the operating personnel of boilers to be licensed by examination should consider inclusion of combustion air, venting and combustion principles in their curriculum and examination.

(note 1) *As of July 1, 1999, the City of Seattle has adopted the fuel-train portion of CSD-1. Combustion air and venting requirements are covered in the Mechanical Code.*



Source: In depth Investigations FY 92, U.S. Consumer Product Safety Commission /EHPA
* Furnace as categorized here is assumed to include a combination of forced air furnaces and boilers

A THEORETICAL BASIS FOR BLOW DOWN by Giovanni

In reading the very good articles by Tim Swanson (Seattle Steamer, June 1999) and by James Dorwin (see page 3 of this issue), I began to wonder about the role of blow down in boilers.

How do we know how much blow down is enough? If the blow down is not sufficient, scale will affect the efficiency of the boiler, or, in the worst case, cause overheating, cracking, or weakening of the pressure retaining parts. Excessive blow down, on the other hand, is not desirable either because it affects the cost of operation. It is true that you blow down mud and sediments, but you also blow down the

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chemicals which are the basis for water treatment.

From the point of view of the practicing boiler inspector, the annual internal inspection is the proof of the pudding. If the boiler scaled up from last year, the inspector will recommend an increase in water treatment (or a change in water treatment) and more frequent blow down. On the other hand, if scaling is such as not to raise an alarm, there will be no recommendation. But is this enough to the careful operator? How does he know that his blow down practice is not excessive? And why wait for a year to determine this? Of course careful water analysis will give the operator a range of acceptable conditions, but the same conditions, or equally acceptable results may be reached by more economical means.

And what happens to the smaller plants we see every day, where the operator doe not have the resources to make a good decision. Most often the decision in these cases is "I blow it down when I remember."

Of course, these decisions depend on the water source. **Generalizing**, in Seattle the water seems to be fairly low in those chemicals that produce hard scale, but it has its share of oxygen. And that is why, **generalizing** again, we see more pitting than hard scale.

I was musing on the problem in general, when the question "What happens if we do not blow down the boiler at all" came to my mind. From there I decided to analyze three circumstances, and some of the answers I came up with were very interesting (read counterintuitive).

Now, some of you will see the math and give up immediately, but I urge you to read on, if nothing else to get to the conclusion. The math is based on two old principles. All of you will be familiar with the first one that says "what stays in depends on what goes in minus what goes out". If you balance your checkbook you will know what I am talking about. The second principle is trickier because what goes out in essence depends on what is in, and that changes with time, and this leads to differential equations (equations which have an equation for solution). There is a host of physical phenomena that behaves that way. Cooling is one. If you take your favorite beverage out of the fridge and you notice that it takes five minutes to go from 40 F to 50, that does not mean that it will take another five minutes to go to 60 F. And that is because the rate your favorite beverage exchanges heat with the room depends on its temperature. It exchanges heat like crazy when that difference is big, but it takes forever when the temperatures begin to get close together. And if you drink it right away you will not notice anything, but that is for another article.

CASE 1

Assume a 100 gals container in which pure water goes in at a rate of 1 gpm. From another line, water also goes in at 1 gpm, but at the touch of a switch we can inject ¼ lb of some salt (calcium carbonate or $CaCO3$ is a favorite, but it can be anything) for each gpm. At the same time well mixed water goes out at 2 gpm. The question is how much salt do I have in the container after 8 minutes? A check book approach to this affair is that what goes out is 2 gpm x (#pounds of salt/100 gallons). What goes in is 1 gpm x (1/4 lb) or ¼. If we call W the salt in the tank and dW/dT its change in time, accounting dictates that

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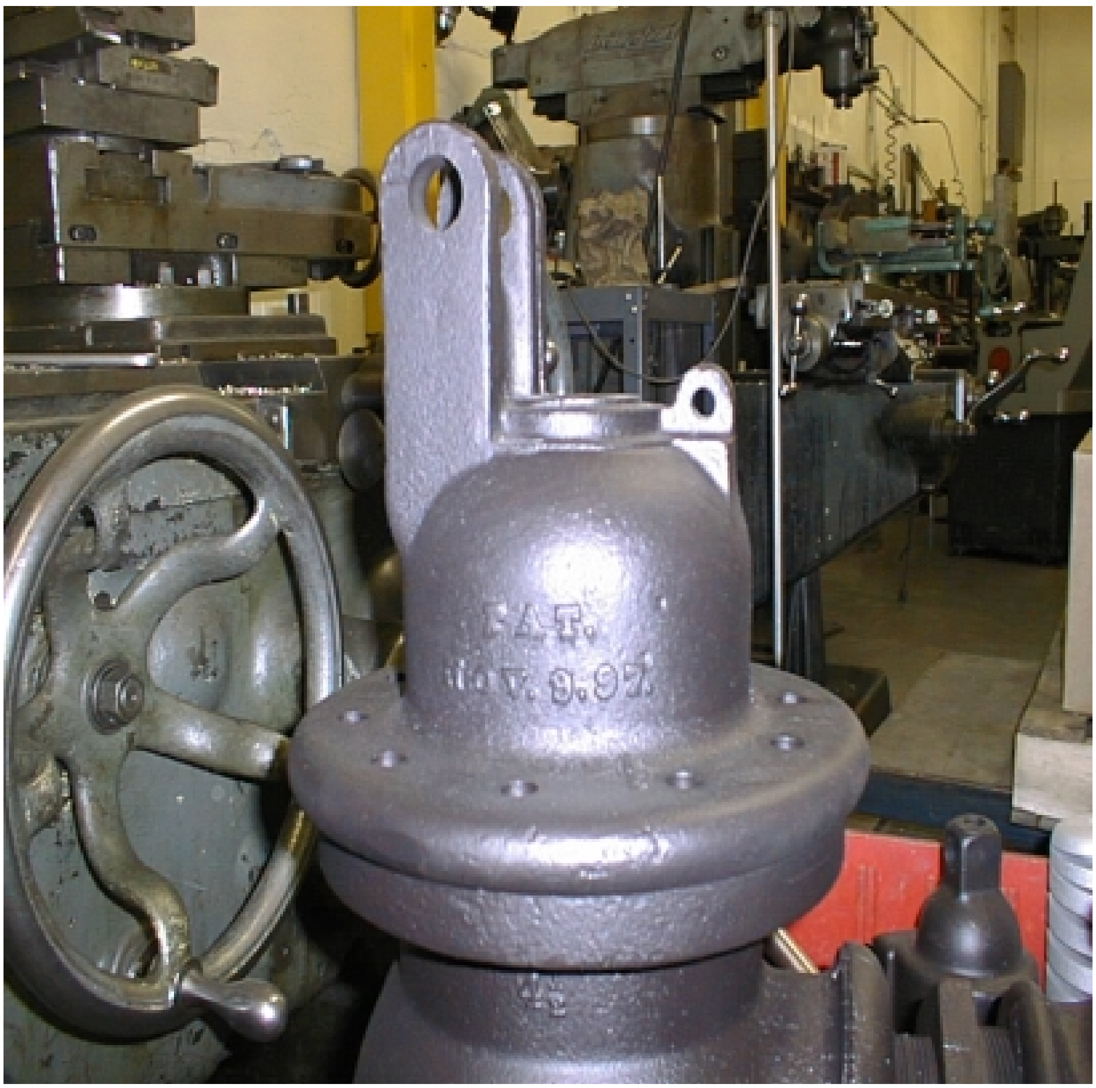
SAFETY VALVES: A LOOK IN THE PAST (AND THAT IS NOT 1997 FOLKS)

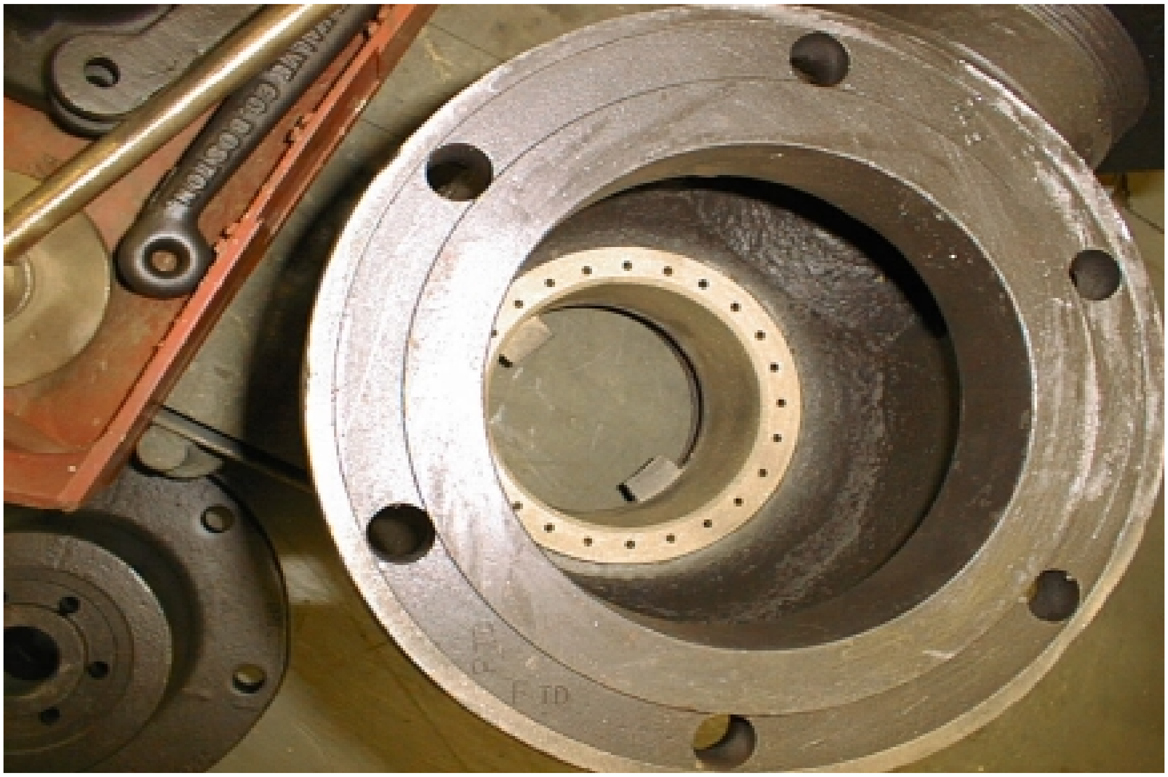
Courtesy of Star Brass

Recently I had a chance to look at some history in the form of two safety valves being refurbished *pro bono* by Star Brass for the Georgetown Power Plant Museum.

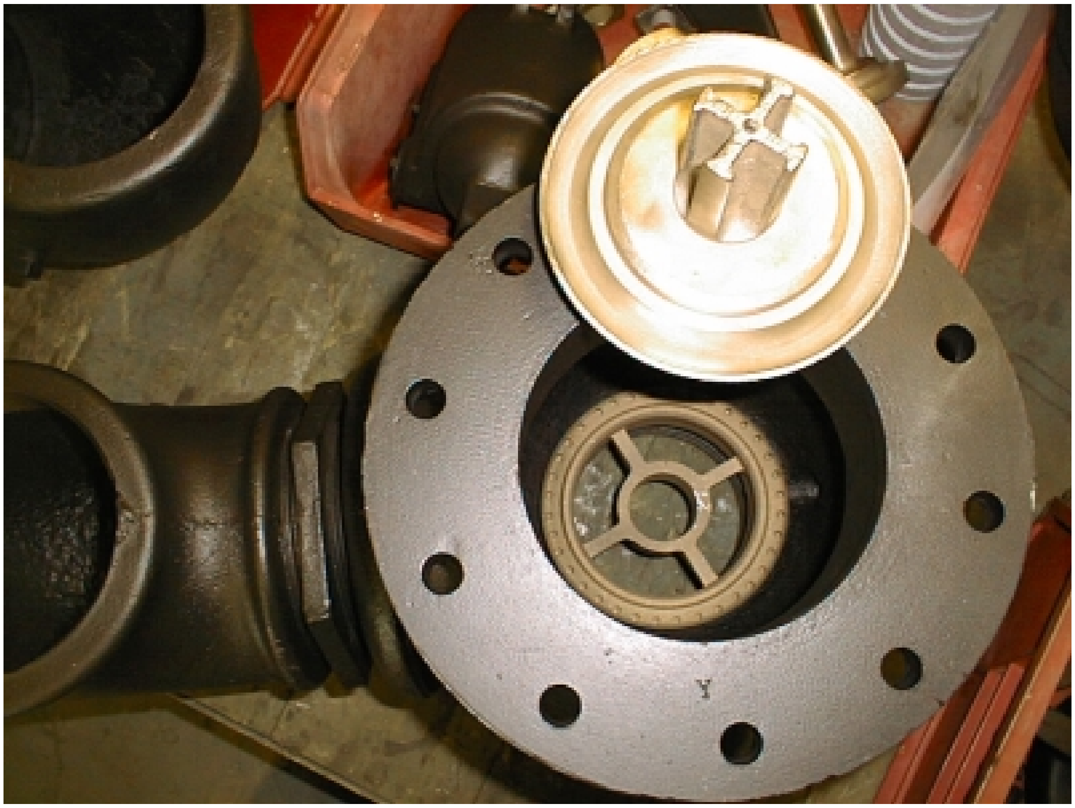
The two safety valves were made by Cosby-and Ashton and on the casting you can clearly see the patent date, November 9, 97. And that is 1897!!

The two safety valves are 4 1/2” flanged inlet, screwed outlet, and that is already an unusual combination. The pictures that follow will reveal some other unusual features. One is that both valves are bottom guided, and although the design is slightly different (one valve has a smaller guide because there is a spider web insert under the seat), the principle is the same.



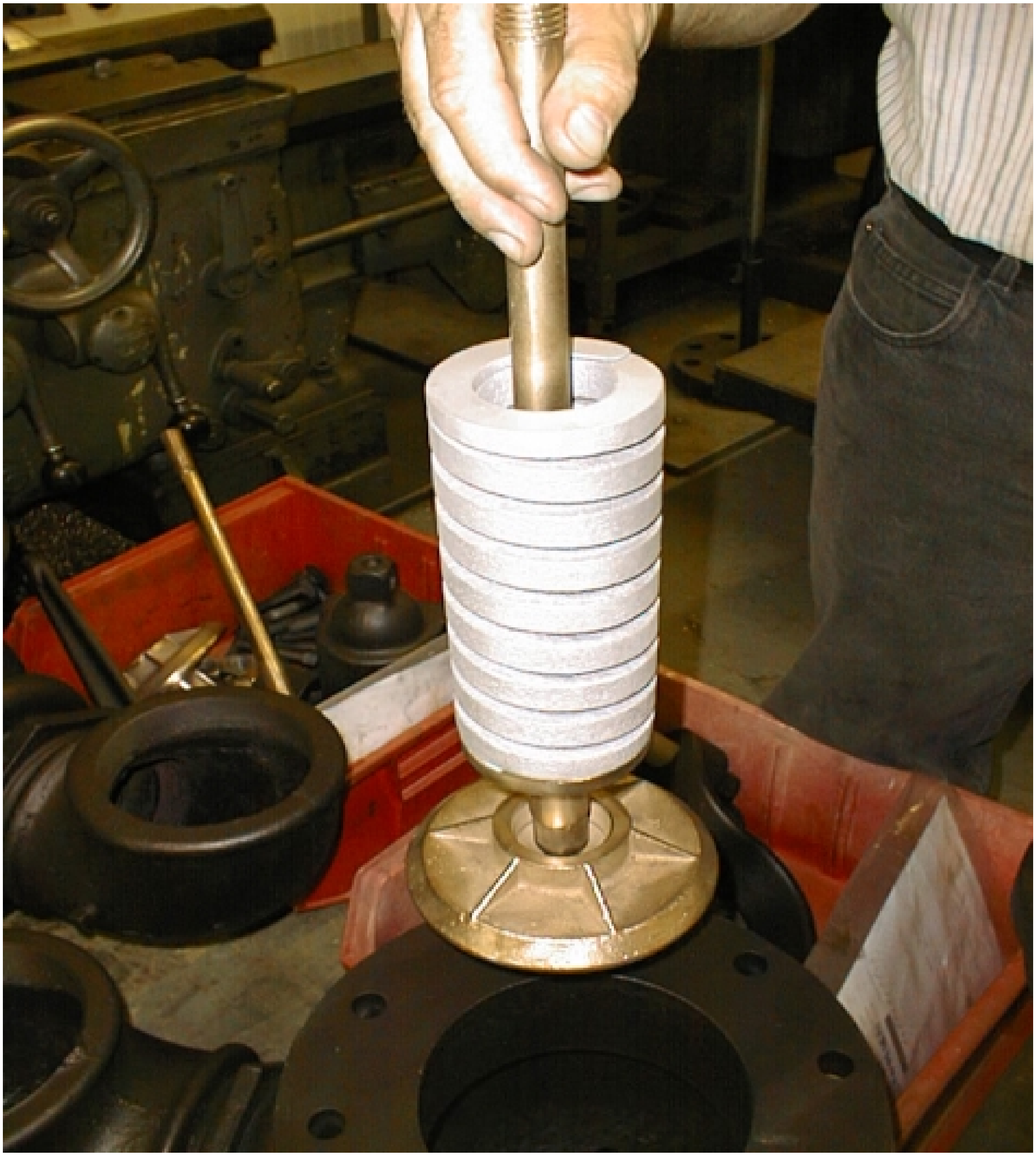


Pictures of the seat and of guided disk and spring. Square springs were favored because they could exert a larger force. The drawback was of course that they did not last as long as the contemporary springs.



Slightly different design. The diameter of the guide is smaller because the guide ran inside a spider web structure.

The picture below illustrates the modern top guided safety valve. Bottom right: Modern Cosby valves.



Simplicity itself. The shaft rests inside the disk, allowing for some rocking motion.

Many thanks also to Lilly Tellefson of the Georgetown Power Plant Museum for her restoration work.

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$$dW/dT = \frac{1}{4} - 0.02\ W$$

There are several techniques to solve this differential equation and there are good books on the subject, and I will not go there. After some tinkering, and by using the initial condition that at T = 0, W = 0, I got the following solution:

$$W = 12.5 - 12.5 \exp(-0.02T)$$

And after 8 minutes you get 1.85 lb of salt in the tank (you may want to think of it in terms of about 2,200 ppm). When I started this exercise, I thought that after weeks, the container would be a block of salt, but the equation tells me otherwise. Basically, the weigh of salt in the tank maxes out at 12.5 lb, **and that to me was a revelation.**

CASE 2

Assume a 100 gallons steam boiler fed at a rate of 2 gpm with water containing 0.000834 lb salt per gal (100 ppm, a pretty reasonable assumption) and leaving as pure steam. This case corresponds to 100% make-up. There is no blow down.
The accounting for this case is pretty simple:

$$dW/dT = 2 \times 0.000834 \text{ or } dW/dT = 0.00168$$

Using 0.0834 (100 x 0.000834) as initial condition, integration gives:

$$W = 0.0834 + 0.00168T$$

Substituting 1440 minutes (one day) and 10,080 minutes (seven days) I get W = 2.5 lb and W = 17 lb respectively. Intuition in this case seems to work, after a while the boiler turns to pure scale.

CASE 3

In reality, other factors will intervene in case 2 and the picture will be a little different. At some concentration, salt will come out of solution, and salt will carry over into the steam.
Assume a 100m gallons steam boiler being fed 1 gpm of water with the same concentration as case 2, 0.000834 lb of salt/gallon. At the same time the boiler is fed 1 gpm of water which has 2% of the salt present in the boiler at a given time. The salt content in the steam is also 2% of the salt present in the boiler. This case corresponds to a 50% condensate recovery. There is no blow down. The accounting goes like this:

leaving the boiler: 2 gpm (.02 x # salt/100 gallons) = 0.0004 W (lb/min)
entering the boiler: 1 gpm (.02 x # salt/100 gallons) =0.0002 W -“-
entering the boiler: 0.000834 lb/min

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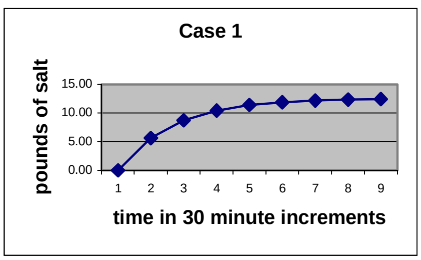
dW/dT = 0.000834 + 0.0002W - 0.0004W or dW/dT = 0.000834 - 0.0002W

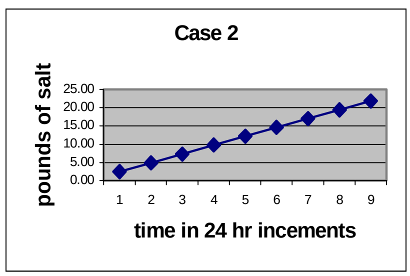
Solution of this differential equation is similar to case 1, except that the initial condition is 100 x 0.000834. After some trafficking, I get a solution that looks like this:

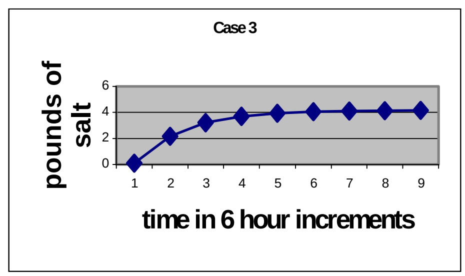
W = 4.17 - 4.09 exp(-0.002T)

and for large times W is 4.17 lb a result similar to case 1 and, for me, counterintuitive.
The lesson I got from this exercise, is that in some cases, scaling is self limiting, and the importance of condensate recovery is evident.

Readers are encouraged to explore other cases, and in particular the case in which a blow down exist. You have the technique to determine how long of a blow down and how frequent does it need to be to keep the concentration in the boiler within the limits needed to control scale.







(**On Stresses**....Continued from page 1)

teresting twist in the picture. Many years ago, I got tangled in a case where the front end of the automobiles a police department back east had purchased a couple of years before were cracking. It turned out that the purchasing department had customized their new vehicles and the manufacturer had installed some heavier suspensions.

“You know, our guys go over a lot of side walks, bumps, etc., and they need some heavier equipment.” was the explanation. Well, when it comes to fatigue (bending or torsion), thicker is not better. In a bar, going from a diameter of 1/4” to 2” you get penalized by as much as 15% (for non-round sections the diameter would be the section depth, for a fillet weld it would be the leg). Other killers when fatigue is a consideration are temperatures above 160 F, notches of course (of which corrosion is a special case), and plating.

Safety factor is another term which can be misleading. In the ordinary sense, it is the **minimum strength** of a steel over the **maximum stress.** Although it may be easy to determine the maximum stress (that one obtained from the largest combination of external loads), the minimum strength may be difficult to determine, other than in a statistical sense. Which translates into “Read the footnotes” when you rely on tables, codes and standards.

I will make two last points. One is that the ASME is a standard that provides for **minimum** requirements. All users are cautioned to the fact that special considerations may require an approach more conservative than the 3.5 factor.

The other is that compliance with the 1999 addenda will be required from January 1, 2000, However, the ASME Code allows manufacturers to use addenda and stamp their vessels accordingly after its publication. I suspect that some jurisdictions may not adopt the new addenda (jokingly, one guy told me that they will wait to adopt it until next year when the safety factor will be 3.0) or adopt it with restrictions. As usual, to avoid disappointments, check with the jurisdiction where the vessel will be installed.

Look Mom, No Phones, No computers by Giovanni

During one of our periodic emergency response reviews, we postulated a situation in which the various sections of DCLU were left without telephones and without computers for five days, presumably because of a Y2K occurrence, although this was not the only scenario envisioned.

As far as the Boiler Section was concerned, we decided that the best way to serve the public was for a group of inspectors to remain in the office, so that the public or other city personnel knew where to find us. The reasoning behind it was that although we were without phones and computers the public knew where to contact us by foot or automobile with some degree of certainty.

To complement the first group, a second group of inspectors would visit by automobile or by foot and offer assistance to some users whose ability to provide steam for heating, sterilization, etc. is critical to the community.

Again, this applies to the boiler section only. As usual, your comments would be appreciated.

ASME Code for Pressure Piping, B-31.1 by Giovanni

As many of you know, this standard has been adopted in the City of Seattle for many years. The standard covers high pressure piping, but piping for Section IV Heating Boilers was not included in B-31.1. A recent interpretation by the ASME puts a new spin on the subject. I am referring to interpretation 32.4 issued June 18, 1998.

You are encouraged to read the interpretation, but basically, the low side of a pressure reducer without by-pass installed in accordance with the requirements of para. 122.5 and operating at 10 psi falls within the scope of B31.1

Near the head of Princess Street in Edimburgh, Scotland, stands the Balmoral Hotel. Perpendicular to Princess street and across from the Balmoral is an insignificant street-almost an alley by U.S. standards-but a typical ancient street of European nations, and on the first corner of this winding alley is the old Royal Café. Go there; the restaurant is rather small, but the food is great. In the same room, but separated by a partial wall about seven feet high, and open to the top, is a larger room, hosting a lively pub brimming with laughter and gaiety every night.

In that pub, on the wall, are several pictures about four feet square, made up of tiles, each about 5” by 5”. Not many people pay attention to those pictures that portray important happenings in history. But a boiler inspector would, because one of them depicts two men bending over a small engine that is puffing steam. One man is James Watt, and the other

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is Matthew Bolton. Watt says, "There is no limit to the speed if the works can be made to stand" And beneath is a plaque with the inscription:

James Watt, inventor of the condensing engine,
and his partner, Matthew Bolton

COMBINATION WATER HEATERS REVISITED By Giovanni

In the March 1999 issue of the Steamer we discussed the rules under which the Seattle Boiler and Pressure Vessel Code exempts combination water heaters used for the dual purpose of supplying potable hot water and space heat. Namely:

The unit must be listed for the dual use
Both potable water and space heating circuits must be connected
Residential use only

Failure to meet any one of these rules mandates the use of a boiler.

What I neglected to mention was that combination water heaters supplying must comply with the Energy Code and the usual considerations of efficiency (80% or higher), pipe insulation (R4 for less than 140 F, R5 for less than 200 F) heat loss calculations, and insulation of the equipment room apply. Combustion air, and venting requirements are those of the Mechanical Code.

The *Steamer* is generally published quarterly by the City of Seattle, Department of Design, Construction & Land Use, Boiler Pressure Systems Inspection Section. The intent of the publication is to provide information to interested persons in related fields. Readers are welcome to submit material for publication (subject to approval). Any materials submitted for publication will become the property of the Department unless prior arrangements are made. Readers are welcome to reprint any original material (the copyrights of others must be respected); we ask only that you credit the *Steamer* as the source.

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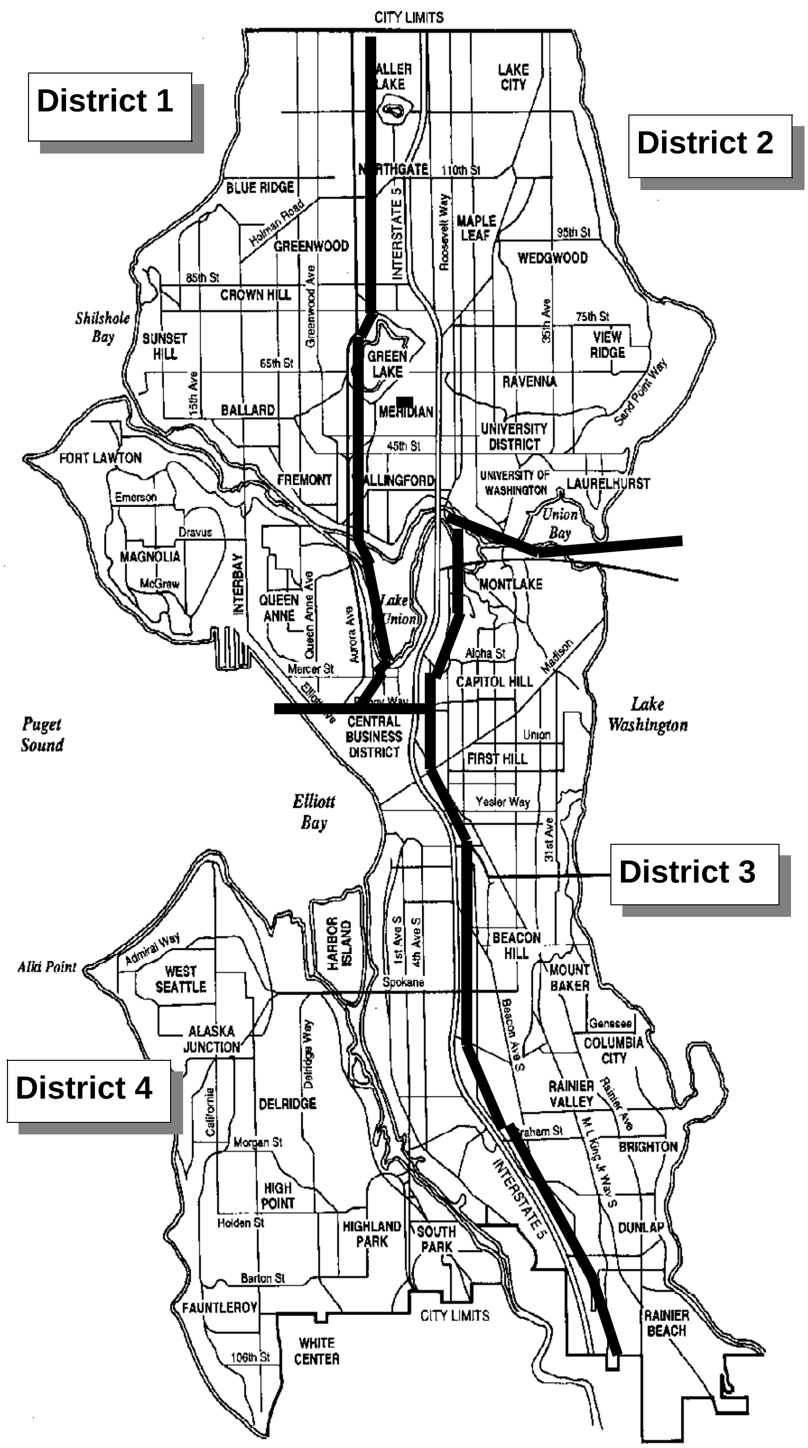
Monthly Meetings are held on the first *working* Monday of each month at Andy's Diner, 2963 - 4th Ave S., approximately two blocks north of Spokane Street. From I-5, take the Spokane Street exit, stay to your right, take the 4th Ave S. exit, then north a few blocks to the restaurant which will be on your left. Lunch is at noon and the meeting is called to order at 12:30 PM.

Inspection Districts in Seattle



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Seattle Public Utilities Department

Back Flow Prevention Questions/ Insp.

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Bob Eastwood 206-233-2635
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Plumbing Inspection In Seattle

Dick Andersen, Chief 206-233-7914
Ginger Ohrmundt, Permits 206-684-5198
Inspection Requests 206-233-2621

State of Washington Boiler Inspection

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FAX 360-902-5292

Bellingham

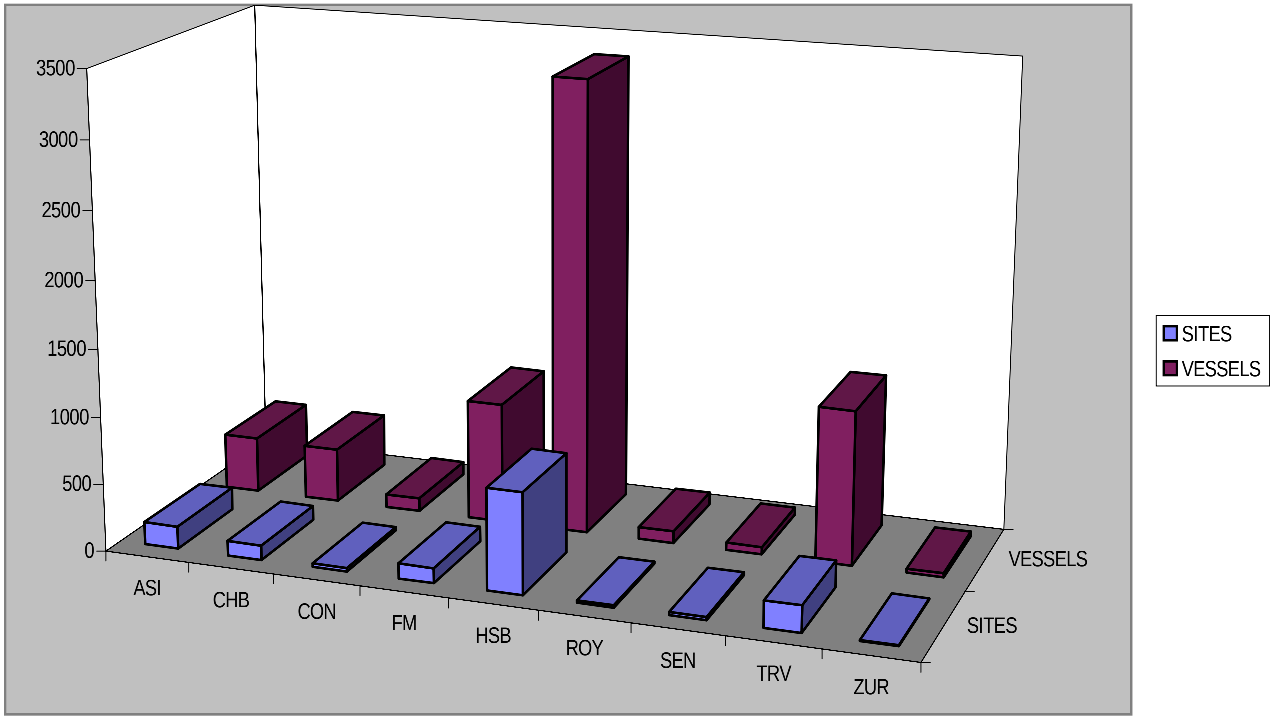
Linda Williamson 360-647-7317

Bremerton

Karen Boyd 360-415-4038

Everett

SITES AND VESSELS CURRENTLY INSURED - AS OF AUGUST 1999



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